PATENT OFFICE

JAPANESE GOVERNMENT

This is to certify that the annexed is a true copy of the following application as filed with this Office.

Date of Application: November 22, 1999

Application Number: 11-331419

Applicant(s): SANYO Electric Co., Ltd.

November 10, 2000

Commissioner, Patent Office — Kohzoh OIKAWA (Official Seal)

Certification No.: 2000-3093673

[Title of the Document] Petition of Patent

[Reference No.] K1B0991038

[Filing Date] November 22, 1999

[To] The Commissioner of the Patent Office

[International Patent Classification] G11B 20/10

[Inventor]

(Address) C/O 5-5, Keihan-Hondori 2-chome, Moriguchi-shi, Osaka

(Name) Koji HAYASHI

[Applicant for Patent Application]

(Applicant Registration No.) 000001889

(Name) SANYO Electric Co., Ltd.

[Agent]

(Registration Number) 100082500

(Patent Attorney)

(Name) Tsutomu ADACHI

(Tel No.) 052-231-7835

[Amount of Charge]

(Receipt Number for Advance Payment) 007102

(Amount of Payment) 21,000 yen

[List of Documents Attached]

(Name of Document) Specification 1

(Name of Document) Drawings 1

(Name of Document) Abstract 1

(Number of General Power of Attorney) 9804525

[Title Of the Document] Specification

[Title of the Invention] DATA RECORDER

[Scope of Claims]

[Claim 1] A data controller including:

a buffer memory for storing input data input from an external device; and

a recording means for irradiating a recording medium with a laser beam in accordance with the input data and recording the input data stored in the buffer memory to the recording medium, the data recorder being characterized by:

a buffer underrun determining means for determining whether the buffer memory has reached a state in which buffer overrun has occurred, which is a phenomenon in which the data capacity of the buffer memory becomes empty;

wherein recording is interrupted at a timing in which the power level of the laser beam irradiated to the recording medium from the recording means becomes low when the buffer underrun determining means determines that a buffer overrun has occurred during recording; and

subsequently, recording is restarted when the external device stores new input data in the buffer memory and the buffer underrun determining means determines that the buffer underrun has ended, and the power level of the laser beam irradiated to the recording medium when restarting recording is decreased.

[Claim 2] The data recorder according to claim 1 being further characterized by:

a recording position extracting means for extracting a recording position of the recording means; and

a recording position address memory for storing the address of a recording position at which recording was interrupted extracted by the recording position extracting means;

wherein the recording is interrupted and the address of the recording position extracted by the recording

position extracting means at that point is stored in the recording position address memory when the buffer underrun determining means determines that buffer underrun is occurring during recording;

subsequently, recording is restarted by returning to the recording position in accordance with the content stored in the recording position address memory when the external device stores new input data in the buffer memory and the buffer underrun determining means determines that the buffer underrun has ended.

[Claim 3] The data recording controller according to claim 2 being further characterized by:

an encoder for reading the input data stored in the buffer memory and encoding the input data to recording data that is recorded on the recording medium;

wherein the recording means records the recording data encoded by the encoder on the recording medium.

[Claim 4] The data recorder according to claim 3, further being characterized by:

a reproducing means for reproducing the recording data recorded on the recording medium;

a recording position detecting means for comparing the address of the recording position extracted by the recording position extracting means and the address stored in the recording position address memory to detect whether the two addresses match;

a signal synchronizing means for synchronizing the recording data encoded by the encoder with recording data reproduced from the recording medium by the reproducing means;

wherein the recording is interrupted and the recording position address memory stores the address of the recording position extracted by the recording position extracting means at that point when the buffer underrun determining means determines that buffer underrun is occurring during

recording;

subsequently, the reproducing means returns to a predetermined recording position at which recording data has already been recorded to the recording medium and the synchronizing means synchronizes the recording data encoded by the encoder with the recording data reproduced from the recording medium to synchronize the recording data recorded on the recording medium after restarting recording with the recording data recorded on the recording medium prior to the interruption of the recording when the external device stores new input data in the buffer memory and the buffer underrun determining means determines that the buffer underrun has ended; and

the recording means restarts recording continuously from a position following the recording position of the recording medium at the point of time recording is interrupted when the recording position detecting means detects the matching of the addresses.

[Claim 5] The data recorder according to claim 4 being further characterized by:

a buffer address memory for storing an address in the buffer memory of the input data read from the buffer memory;

a buffer position detecting means for comparing the address of the buffer memory of the input data read from the buffer memory with the address stored in the buffer address memory and detecting whether the two addresses match; and

a retry determining means for repeating reproduction during recording restart until the detection of the matching of the addresses by the recording position detecting means detects and the detection of the matching of the addresses are performed simultaneously, and restarting recording when the detection of the matching of the addresses by the recording position detecting means detects and the detection of the matching of the addresses are performed simultaneously.

[Detailed Description of the Invention]
[0001]
[Technical Field of the Invention]

The present invention relates to a data recorder, and more particularly, to a data recorder having a buffer memory for storing data provided from an external device and recording the stored data of the buffer memory on a recording medium.

[0002]
[Prior Art]

In the prior art, an optical disc recorder that uses an optical disc as a recording medium is known as a data recorder for recording data to a recording medium.

A CD-DA family compact disc-recordable (CD-R) drive is one type of optical disc recorder that is widely used. A CD-R is a so-called write-once optical disc on which data is written only once. The recorded data cannot be physically deleted. A laser beam is irradiated against the optical disc from an optical head of the CD-R drive. The heat of the laser beam melts a dye and forms recording pits on a recording layer of the optical disc. Data is recorded on the disc by changing the reflecting rate of the recording layer.

[0003]
[Problems that the Invention is to Solve]

The optical disc recorder includes a buffer memory and an encoder. The buffer memory temporarily stores data provided from an external device, such as a personal computer. The encoder reads the data from the buffer memory and encodes the read data to record the data on the optical disc.

[0004]

In such an optical disc recorder, if, for example, the rate of data transmission from the external device is slower than the recording data transmission rate of the optical

disc (write speed), the transmission rate of the recording data output from the encoder is faster than the transmission rate of the data provided to the buffer. This decreases the amount of data stored in the buffer memory. If the decrease continues, the data amount ultimately becomes null and the buffer memory becomes empty. As a result, the desired input data cannot be input to the encoder. This stops the stream of data recorded to the optical disc.

[0005]

In this manner, the phenomenon in which the rate of data transmission from the external device becomes slower than the recording data transmission rate of the optical disc and the data capacity of the buffer memory becomes empty is referred to as buffer underrun. The interruption in the data recorded on the optical disc resulting from buffer underrun is referred to as a buffer underrun error.

[0006]

Data is recorded on an optical disc using a recording technique that designates the file group recorded on the optical disc (e.g., disc at once, track at once). Thus, if a buffer underrun error occurs, the entire optical disc becomes unusable when employing disc at once, and the track undergoing recording becomes unusable when employing track at once.

[0007]

Recent CD-R drives record data at a speed four times or eight times the normal recording speed. Further, recent personal computers have multitasking functions to operate CD-R drives. This has increased the tendency of the occurrence of buffer underrun errors.

[0008]

Packet writing is one type of data recording that records data in packet units. Packet writing records data on an optical disc when the data reaches the capacity of the packet. This prevents the occurrence of buffer underrun

errors. However, link blocks must be formed to connect packets in packet writing. The link blocks decrease the recording capacity of the optical disc. Further, there are CD-ROM drives that are not capable of handling packet writing. Such CD-ROM drives cannot reproduce data written to optical discs through packet writing. In other words, the CD-ROM compatibility required by the CD-R standard (Orange Book Part II) does not include packet writing. For example, packet writing cannot be applied for a CD-DA player. Thus, a CD-R drive cannot record CD-DA audio data through packet writing. Accordingly, there is a need for preventing buffer underrun errors without employing packet writing.

[0009]

A CD-recordable write (CD-RW) drive is another type of optical disc recorder that is widely used. A CD-RW drive irradiates a laser beam from an optical head against an optical disc. The heat of the laser beam causes phase changes between amorphic and crystalline to form recording pits on the recording layer of the optical disc. This changes the reflecting rate of the recording layer and records data on the optical disc. Data can be repeatedly rewritten to optical discs used by the CD-RW drive. Accordingly, the optical disc remains usable even if a buffer underrun error occurs. However, when a buffer underrun error occurs, the data file that was being recorded before the occurrence of the buffer underrun error must be recorded again. This wastes the recording performed prior to the occurrence of the buffer underrun error and increases the recording time.

[0010]

A magneto-optic disc recorder is another type of known data recorder. The magneto-optic disc recorder irradiates a laser beam from an optical head against a magneto-optic disc. This applies residual magnetization to the recording

layer of the optical disc and records data on the magneto-optic disc. Mini disc (MD) drives are widely used magneto-optic disc recorders. However, MD drives have the same problem as CD-RW drives.

[0011]

Accordingly, it is an object of the present invention to provide a data recorder that records data in a manner that the continuity of the data is ensured even if the recording of data to a recording medium is interrupted.

[0012]

[Means for Solving the Problems and Effect of the Invention]

To achieve the above object, the invention of claim 1 is a data controller including a buffer memory for storing input data input from an external device, and a recording means for irradiating a recording medium with a laser beam in accordance with the input data and recording the input data stored in the buffer memory to the recording medium. The gist of the data recorder being a buffer underrun determining means for determining whether the buffer memory has reached a state in which buffer overrun has occurred, which is a phenomenon in which the data capacity of the buffer memory becomes empty, wherein recording is interrupted at a timing in which the power level of the laser beam irradiated to the recording medium from the recording means becomes low when the buffer underrun determining means determines that a buffer overrun has occurred during recording, and subsequently, recording is restarted when the external device stores new input data in the buffer memory and the buffer underrun determining means determines that the buffer underrun has ended, and the power level of the laser beam irradiated to the recording medium when restarting recording is decreased.

[0013]

Accordingly, in the invention of claim 1, when the transmission rate of the data provided from the external

device is slower than the transmission rate of the data recorded in the recording medium, the amount of data stored in the buffer memory decreases. When this state continues, the data capacity of the input data stored in the buffer memory becomes empty and causes buffer underrun. Thus, the buffer underrun determining means determines that a buffer underrun may occur in the buffer memory before the buffer underrun occurs. Recording is restarted based on the determination result. Thus, recording data is recorded continuously from the recording position of the recording medium at which the recording was interrupted. As a result, for example, when using an optical disc, which complies with a CD-R or CD-RW standard, as the recording medium, the occurrence of a buffer underrun error, in which the data recorded to the optical disc is interrupted, is prevented without perfoming packet writing as the recording method.

[0014]

If the power level of the laser beam irradiated to the recording medium from the recording means is high When recording is interrupted, an increase in the power level when recording is restarted requires time until the power level reaches a desired level. This time delay produces a non-recording region in the recording medium and interrupts the recording data.

[0015]

When restraint recording, the irradiation position of the laser beam emitted to the recording medium from the recording medium deviates. This may record (rewrite) recording data again to a position in which recording data has already been recorded when recording was interrupted. In such a case, the laser beam is irradiated again to the position in which the recording layer of the recording medium has already been formed. Thus, if the power level of the laser beam is high when recording restarts, the diameter of the recording pit becomes excessively large and normal

recording cannot be performed.

[0016]

Accordingly, in the invention of claim 1, recording is interrupted at a timing in which the power level of the laser beam irradiated to the recording medium decreases, and the power level of the laser beam irradiated to the recording medium from the recording means when restarting recording is decreased. This eliminates the need to increases the power level of the laser beam irradiated from the recording medium when restarting recording and prevents abnormal formation of the recording medium in the above manner even when rewriting recording data during recording restart.

[0017]

In the invention described in claim 2, the data recorder according to claim 1 includes a recording position extracting means for extracting a recording position of the recording means, and a recording position address memory for storing the address of a recording position at which recording was interrupted extracted by the recording position extracting means. The recording is interrupted and the address of the recording position extracted by the recording position extracting means at that point is stored in the recording position address memory when the buffer underrun determining means determines that buffer underrun is occurring during recording. Subsequently, recording is restarted by returning to the recording position in accordance with the content stored in the recording position address memory when the external device stores new input data in the buffer memory and the buffer underrun determining means determines that the buffer underrun has ended.

[0018]

The invention of claim 2 further ensures the advantages of the invention of claim 1.

In the invention described in claim 3, the data recording controller according to claim 2 further includes an encoder for reading the input data stored in the buffer memory and encoding the input data to recording data that is recorded on the recording medium. The recording means records the recording data encoded by the encoder on the recording medium.

[0019]

The invention of claim 3 further ensures the advantages of the invention of claim 2.

In the invention described in claim 4, the data recorder according to claim 3 further includes a reproducing means for reproducing the recording data recorded on the recording medium, a recording position detecting means for comparing the address of the recording position extracted by the recording position extracting means and the address stored in the recording position address memory to detect whether the two addresses match, and a signal synchronizing means for synchronizing the recording data encoded by the encoder with recording data reproduced from the recording medium by the reproducing means. The recording is interrupted and the recording position address memory stores the address of the recording position extracted by the recording position extracting means at that point when the buffer underrun determining means determines that buffer underrun is occurring during recording. Subsequently, the reproducing means returns to a predetermined recording position at which recording data has already been recorded to the recording medium and the synchronizing means synchronizes the recording data encoded by the encoder with the recording data reproduced from the recording medium to synchronize the recording data recorded on the recording medium after restarting recording with the recording data recorded on the recording medium prior to the interruption of the recording when the external device stores new input

data in the buffer memory and the buffer underrun determining means determines that the buffer underrun has ended. The recording means restarts recording continuously from a position following the recording position of the recording medium at the point of time recording is interrupted when the recording position detecting means detects the matching of the addresses.

[0020]

The invention of claim 4 further ensures the advantages of the invention of claim 3.

In the invention described in claim 5, the data recorder according to claim 4 includes a buffer address memory for storing an address in the buffer memory of the input data read from the buffer memory, a buffer position detecting means for comparing the address of the buffer memory of the input data read from the buffer memory with the address stored in the buffer address memory and detecting whether the two addresses match, and a retry determining means for repeating reproduction during recording restart until the detection of the matching of the addresses by the recording position detecting means detects and the detection of the matching of the addresses are performed simultaneously, and restarting recording when the detection of the matching of the addresses by the recording position detecting means detects and the detection of the matching of the addresses are performed simultaneously.

[0021]

In the invention of claim 5, when the detecting timing of the matched state differs in both the recording position detecting means and the buffer position detecting means, the recording restart reproduction is repetitively performed. that is, in a normal state, the detection of a matching in both the recording position detecting means and the buffer position detecting means is supposed to be performed simultaneously. However, when any one of the elements

forming the data recorder functions erroneously due to one reason or another (e.g., an external impact being applied to the data recorder), the detection of the matching may not be performed simultaneously. Accordingly, in the invention of claim 5, the retry determining means repetitively restarts reproduction to avoid the influence of external disturbances and ensure the prevention of a buffer underrun error.

[0022]

The corresponding relationship of the elements described in the above [Scope of Claims] and [Means for Solving the Problems and Effect of the Invention] with respect to the members described in the following [Embodiments of the Invention] is as described below.

"Recording means" includes a spindle motor 2, a spindle servo circuit 3, an optical head 4, a laser drive circuit 16, and an access control circuit 19.

"Recording medium" corresponds to an optical disc 32.

"External device" corresponds to a personal computer 31.

"Buffer underrun determining means" corresponds to a buffer underrun determination circuit 20.

[0024]

"Reproducing means" corresponds to a spindle motor 2, a spindle servo circuit 3, an optical head 4, an RF amplifier 5, a head servo circuit 6, a decoder 7, a subcode decoding circuit 8, a wobble decoder 9, and an access control circuit 19.

"Recording position recording medium" corresponds to a sector position in the optical disc 32.

[0025]

"Recording position extracting means" corresponds to an ATIP decoding circuit 10.

"Recording position address memory" corresponds to an address memory 48.

"Recording position detecting means" corresponds to a

location detection circuit 46.

"Signal synchronizing means" corresponds to a signal synchronizing circuit 42.

[0026]

"Buffer address memory" corresponds to an address memory 47.

"Buffer position detecting means" corresponds to a location detection circuit 45.

"Retry determining means" corresponds to a retry determining circuit 44.

[0027]

[Embodiments of the Invention]

An embodiment of the present invention will now be described with reference to the drawings.

Fig. 1 is a block circuit diagram schematically showing the structure of a CD-R drive 1.

[0028]

The CD-R drive 1 includes a spindle motor 2, a spindle servo circuit 3, an optical head 4, an RF amplifier 5, a head servo circuit 6, a decoder 7, a subcode decoding circuit 8, a wobble decoder 9, an ATIP decoding circuit 10, an external connection terminal 11, an interface 12, a buffer memory 13, an encoder 14, an encoder internal RAM 15, a laser drive circuit 16, a crystal oscillation circuit 18, an access control circuit 19, a buffer underrun determination circuit 20, a recording control circuit 21, and a system control circuit 22. The CD-R drive 1 is connected to a personal computer 31 via the external connection terminal 11 to record (write) data, which is provided from the personal computer 31, on an optical disc 32 that complies with the CD-R standards. Further, the CD-R drive 1 provides the personal computer 31 with data reproduced (read) from the optical disc 32.

[0029]

The spindle motor 2 rotates the optical disc 32.

The spindle servo control circuit 3 controls the spindle motor 2 so that the optical disc 32 is rotated using the constant linear velocity (CLV) method in accordance with the rotation control signal generated by the wobble decoder 9.

[0030]

When reproducing (reading) data, the optical head 4 irradiates a relatively weak laser beam against the optical disc and, from the reflected laser beam, generates a RF signal (high frequency signal) in correspondence with the data recorded on the optical disc. When recording (writing) data, the optical head 4 irradiates a relatively intense laser beam (several tens of times greater than the data reading laser beam) against the optical beam 32 to form recording pits on the recording layer of the optical disc 32 and change the reflecting rate of the recording layer to record data. In synchronism with the recording of data, the optical head 4 generates the RF signal in correspondence with the recorded data from the reflected laser beam.

[0031]

The RF amplifier 5 amplifies the RF signal, which is provided from the optical head 4, and digitizes the amplified RF signal to generate a digital data signal.

The RF signal of the optical head 4 is fed back to the head servo circuit 6 via the RF amplifier 5. The head servo circuit 6 uses the RF signal to perform focusing control, tracking control, and sled feed control. Focusing control focuses the laser beam on the recording layer of the optical disc 32. Tracking control tracks the laser beam along a signal track of the optical disc 32. Sled feed control moves the optical head 4 in the radial direction of the optical disc 32.

[0032]

The decoder 7 decodes the digital data provided from the RF amplifier 5. Further, the decoder 7 generates a pit

clock from the digital data and separates a subcode from the digital data to generate a subcode synchronizing signal.

The subcode decoding circuit 8, which is incorporated in the decoder 7, decodes the subcode. Further, the subcode decoding circuit 8 generates subcode Q channel data (hereafter referred to as sub-Q data) from the decoded subcode.

[0033]

The wobble decoder 9 extracts a wobble component of 22.05kHz from a pre-groove signal of the optical disc 32 that is included in the digital data provided from the RF amplifier 5. Then, the wobble decoder generates the rotation control signal of the optical disc 32 from the wobble component.

[0034]

The ATIP decoding circuit 10, which is incorporated in the wobble decoder 9, uses the wobble component to decode an absolute time in pre-groove (ATIP) and extract absolute time information, or an ATIP address, from the ATIP. The absolute time information indicates addresses of locations in the recording medium.

The interface 12 controls data transmission between the personal computer 31 and the CD-R drive 1.

[0035]

The buffer memory 13 is a ring buffer that includes a synchronous dynamic random access memory (SDRAM), which preferably has a FIFO configuration, and the buffer memory 13 stores data provided from the personal computer 31 via the interface 12. Data stored at one address of the buffer memory 13 corresponds to data recorded at one sector of the optical disc 32.

[0036]

An interrupt/restart circuit 43 of the system control circuit 22 controls the encoder 14. The encoder 14 reads the data stored in the buffer memory 13 in sector units and

encodes the data into recording data for the optical disc 32. The RAM 15, which is incorporated in the encoder 14, stores the necessary data for encoding by the encoder 14 and intermediate operation encoding data.

[0037]

When performing data encoding in compliance with the CD-ROM standard, the encoder 14 adds a synch byte, a header, CD-ROM data error detection code (EDC), and an error correction code (ECC) to the data. The encoder 14 further performs error correction using a cross interleaved Reed-Solomon code (CIRC), which is a CD error correction code, and eight to fourteen modulation (EFM) on the data. Further, the encoder 14 adds a subcode, which includes the sub-Q data, and a synchronizing signal of the subcode to the data.

[0038]

The interrupt/restart circuit 43 also controls the laser drive circuit 16, which provides a laser drive signal to the laser beam source of the optical head 4.

The voltage of the drive signal is constant when reproducing data and varied in accordance with the recording data output from the encoder 14 when recording data. When the recording data output from the encoder 14 is low (L), recording pits are not formed on the recording layer of the optical disc 32. Thus, the drive signal is set so that its voltage is the same as when data is reproduced. When the recording data is high (H), recording pits are formed on the recording layer of the optical disc 32. Thus, although the voltage of the drive signal differs between track positions, the drive signal is set so that its voltage is several tens of times greater than during data reproduction.

[0039]

The crystal oscillation circuit 18 generates an oscillation signal based on the oscillation of a crystal oscillator.

The access control circuit 19 selectively refers to the subcode address of the absolute time information in the sub-Q data and the ATIP address of the absolute time information in the ATIP to control the recording control circuit 21 and the head servo circuit 6. This controls access to the optical disc 32.

[0040]

The data provided to the buffer memory 13 is stored in the buffer memory 13 in a predetermined address order. The buffer underrun determination circuit 20 directly or indirectly determines the amount of data stored in the buffer memory 13 from the address at which writing or reading is presently performed. Based on the data amount, the buffer underrun determination circuit 20 determines whether or not the buffer memory 13 is in a state in which buffer underrun may occur.

[0041]

Based on the determination result of the buffer underrun determination circuit 20 and in response to a command provided from the personal computer 31, the recording control circuit 21 controls the interface 12, the access control circuit 19, and the system control circuit 22.

[0042]

The system control circuit 22 includes a system clock generation circuit 41, a signal synchronizing circuit 42, the interrupt/restart circuit 43, a retry determination circuit 44, location detection circuits 45, 46, and address memories 47, 48. These circuits 41-48 are laid out on the same chip of an LSI substrate.

[0043]

The system clock generation circuit 41 generates from the oscillation signal of the crystal oscillation circuit 18 a reference clock used when recording data. Further, the generation circuit 41 uses a pit clock extracted by the

decoder 7 to generate a reproduction clock used when reproducing data. The generation circuit 41 selects the reference clock or the reproduction clock in accordance with the switching control performed by the signal synchronizing circuit 42. The selected clock is used as a system operational clock of the CD-R drive 1. In accordance with the operational clock, the CD-R drive 1 controls the synchronization of the circuits 7-10, 12-16, and 19-22.

[0044]

In accordance with the synchronizing signal of the subcode from the decoder 7 and the sub-Q data from the subcode decoding circuit 8, the signal synchronizing circuit 42 controls the recording control circuit 21 so that the recording data output from the encoder 14 is synchronized with the data recorded on the optical disc 32. When performing this control, the sub-Q data of the subcode decoding circuit 8 is associated with the sub-Q data of the encoder 14 after synchronizing the subcode synchronizing signal of the decoder 7 with the subcode synchronizing signal of the encoder 14. The signal synchronizing circuit 42 controls the system clock generation circuit 41 so that the reference clock or the reproduction clock is output.

[0045]

The recording control circuit 21 controls the interrupt/restart circuit 43. The interrupt/restart control circuit 43 controls the encoder 14 and the laser drive circuit 16 and, when the buffer underrun determination circuit determines that the buffer memory 13 has entered a state in which buffer underrun may occur, provides the address memories 47, 48 with a recording interrupt signal.

[0046]

The address memory 47 stores the address of the read data in the buffer memory 13 when receiving the recording interrupt signal from the interrupt/restart circuit 43.

The address memory 48 stores the address of the ATIP

decoded by the ATIP decoding circuit 10 when receiving the recording interrupt signal from the interrupt/restart circuit 43.

[0047]

When data is reproduced during a recording restart mode, which will be described later, the location detection circuit 45 compares the address of the data read from the buffer memory 13 with the address stored in the address memory 47. If the data address and the stored address are the same, the location detection circuit 45 activates the recording restart signal.

[0048]

When data is reproduced during the recording restart mode, the location detection circuit 46 compares the address of the ATIP decoded by the ATIP decoding circuit 10 with the ATIP address stored in the address memory 48. If the decoded ATIP address and the stored ATIP address are the same, the location detection circuit 46 activates the recording restart signal.

[0049]

The retry determination circuit 44 instructs the recording control circuit 21 to restart the recording operation of the interface 12, the access control circuit 19, and the system control circuit 22 when the restart signals of the location detection circuits 45, 46 are simultaneously activated. When the two restart signals are not synchronously activated (when the restart signals are activated at different timings), the retry determination circuit 44 instructs the control circuit 21 to repeatedly perform data reproduction in the recording restart mode until the two restart signals are synchronously activated.

[0050]

The operation of the CD-R drive 1 will now be discussed.

When a user manipulates the personal computer 31 to

record data, the personal computer 31 generates a command accordingly. The command is transferred to the recording control circuit 21 via the interface 12. In response to the command, the recording control circuit 21 controls the interface 12, the access control circuit 19, and the system control circuit 22 to record data.

[0051]

When recording begins, the signal synchronizing circuit 42 switches the operational clock output of the system clock generation circuit 41 to the reference clock. As a result, the circuits 7-10, 12-16, 19-22 of the CD-R drive 1 are synchronized with the operational clock, or the reference clock.

[0052]

The data provided from the personal computer 31 is stored in the buffer memory via the interface 12 and read from the buffer memory 13 in sector units. The encoder 14 encodes the data read from the buffer memory 13 in sector units to generate recording data.

[0053]

The laser drive circuit 16 provides the optical head 4 with drive signal having a voltage corresponding to the recording data. In accordance with the drive signal, the optical head 4 changes the intensity of the laser beam irradiated against the optical disc 32. This forms recording pits on the recording layer of the optical disc 32 and records data on the optical disc 32. Simultaneously, from the laser beam reflected by the optical disc 32, the optical head 4 reproduces the data recorded on the optical disc 32 as the RF signal.

[0054]

The RF amplifier 5 amplifies the RF signal provided from the optical head 4 to generate digital data. The wobble decoder 9 extracts the wobble component from the digital data and uses the wobble component to generate the

rotation control signal. The ATIP decoding circuit 10 decodes the ATIP using the wobble component and extracts the ATIP address of the absolute time information in the ATIP.

[0055]

In accordance with the rotation control signal, the spindle servo circuit 3 controls the spindle motor 2 so that the optical disc 32 is rotated at a constant linear velocity.

When the transmission rate of the data provided from the personal computer 31 is slower than the transmission rate of the data recorded in the optical disc 32 (write speed), that is, when the transmission rate of the data provided to the buffer 13 is slower than that of the data output from the encoder 14, the amount of data stored in the buffer memory 13 decreases.

[0056]

When this state continues, the data capacity of the input data stored in the buffer memory 13 becomes empty and causes buffer underrun. Thus, the buffer underrun determination circuit 20 determines that a buffer underrun error may occur in the buffer memory 13. The recording control circuit 21 controls the interrupt/restart circuit 43 based on the determination result so that the interrupt/restart circuit 43 outputs the interrupt signal and interrupts the output of the recording data from the encoder 14.

[0057]

In this state, when the level of the recording data output from the encoder 14 goes low, the interrupt/restart circuit 43 outputs the interrupt signal and stops the output of the recording data from the encoder 14.

In response to the interrupt signal, the address memories 47, 48 store the data address of the buffer memory 13. In other words, the address memory 47 stores the buffer memory address of the data read from the buffer memory 13

when receiving the interrupt signal. The address memory 48 stores the ATIP address of the ATIP decoding circuit 10 when receiving the interrupt signal.

[0058]

When the output of the recording data from the encoder 14 is interrupted, the transmission of the drive signal from the laser drive circuit 16 to the optical head 4 is impeded. This stops the emission of the laser beam from the optical head 4 and interrupts the recording of data on the optical disc 32. When the interrupt/restart circuit 43 outputs the interrupt signal, the sector of the data being output from the encoder 14 is recorded on the optical disc 32. The interrupt signal of the interrupt/restart circuit 43 may be output at times between sectors of the recording data.

[0059]

Subsequent to the recording interruption, the data provided from the personal computer 31 is stored in the buffer memory 13 via the interface 12. As the amount of data stored in the buffer memory 13 increases, the state in which a buffer underrun may occur no longer exists. When the buffer underrun determination circuit 20 determines that buffer underrun is not likely to occur, the recording control circuit 21 controls the access control circuit 19 and the system control circuit 22 to perform data reproduction in the recording restart mode.

[0060]

When data reproduction is performed in the recording restart mode, the access control circuit 19 controls the head servo circuit 6. The head servo circuit 6 controls focusing, tracking, and sled feed of the optical head 4 to move the optical head 4 to a sector location that is prior by a predetermined number of sectors from the sector at which the recording interruption occurred. The optical head 4 then irradiates the laser beam from that sector location.

[0061]

The interrupt/restart circuit 43 controls the laser drive circuit 16 so that a drive signal having a constant voltage is output from the laser drive circuit 16. This results in the optical head 4 irradiating the optical disc 32 with a relatively weak laser beam. The reflected laser beam reproduces the data recorded on the optical disc prior to the recording interruption, and the optical head 4 outputs the recording data as the RF signal.

[0062]

The RF signal output from the optical head 4 is amplified by the RF amplifier 5 and converted to digital data. The decoder 7 decodes the digital data, extracts a pit clock from the digital data, and separates a subcode from the digital data. A subcode synchronizing signal is generated from the subcode. The subcode is decoded by the subcode decoding circuit 8 to generate the sub-Q data.

[0063]

When data reproduction in the recording restart mode is started, the signal synchronizing circuit 42 switches the operational clock from the reference clock of the crystal oscillation circuit 18 to the reproduction clock of the decoder 7. The circuits 7-10, 12-16, 19-22 of the CD-R drive 1 are operated in accordance with the reproduction clock. By using the reproduction clock, the data recorded on the optical disc 32 prior to the recording interruption is accurately reproduced.

[0064]

The recording control circuit 21 controls the interrupt/restart circuit 43 to instruct the encoder 14 to restart the output of the recording data. The encoder 14 goes back by a predetermined number of sectors from the data address of the buffer memory 13 at which the recording interruption occurred and starts reading data in sector units from that sector of the buffer memory 13. The encoder 14 adds a synch byte, a header, an EDC, and an ECC to the

read data, performs the CIRC and EFM processes, and adds a subcode, which includes the sub-Q data, and the subcode synchronizing signal to the read data.

[0065]

The drive signal of the laser drive circuit 16 is controlled by the interrupt/restart circuit 43 and is constant during data reproduction in the recording restart mode. In other words, when restarting data reproduction after buffer underrun occurs and interrupts recording, the buffer memory 13 and the encoder 14 perform the same operations as when recording data. However, the drive signal of the laser drive circuit 16 is set to the low level for data reproduction. Accordingly, laser irradiation does not affect the data recorded on the optical disc 32 prior to the interruption.

[0066]

The signal synchronizing circuit 42 controls the access control circuit 19 via the recording control circuit 21 and synchronizes the data recorded on the optical disc 32 with the recording data output from the encoder 14. In other words, the signal synchronizing circuit 42 controls the recording control circuit 21 and the access control circuit 19 so that the subcode synchronizing signal of the decoder 7 is synchronized with the subcode synchronizing signal of the encoder 14 and the sub-Q data of the subcode decoding circuit 8 is associated with the sub-Q data of the encoder 14.

[0067]

The location detection circuit 45 compares the address of the data read from the buffer memory 13 with the address stored in the address memory 47 and outputs a restart signal when the data address and the stored address (address of the data read from the buffer memory 13 when the recording of data read from the buffer memory 13 is interrupted) are the same.

[0068]

The location detection circuit 46 compares the ATIP address of the ATIP decoding circuit 10 with the ATIP address stored in the address memory 48 and activates the restart signal when the ATIP address and the stored address are the same. The ATIP address stored in the address memory 48 is the ATIP address decoded by the ATIP decoding circuit 10 when the recording of data is interrupted.

[0069]

When the restart signals of the location detection circuits 45, 46 are simultaneously output, the retry determination circuit 44 controls the interface 12, the access control circuit 19, and the system control circuit 22 via the recording control circuit 21.

[0070]

The signal synchronizing circuit 42 switches the operational clock of the system clock generation circuit 41 from the reproduction clock to the reference clock when recording is restarted. The same operations are performed as when recording is performed.

[0071]

Upon the restart of the recording, the address memory 48 and the location detection circuit 46 shift the sector location of the optical disc 32 irradiated by the laser beam to the sector location next to the sector location at which data recording was interrupted.

[0072]

In this state, the signal synchronizing circuit 42 synchronizes the recording data output from the encoder 14 with the data recorded on the optical disc 32.

Accordingly, the data of the sector next to the sector at which data recording was interrupted is recorded upon the restart of the recording. In other words, sectors of data are recorded without any interruptions when restarting recording. This ensures the continuity of the recorded data

while preventing the occurrence of a buffer underrun error.

[0073]

As described above, when the level of the recording data output from the encoder 14 goes low, the interrupt/restart circuit 43 outputs the interrupt signal and stops the output of the recording data from the encoder 14. Thus, when the recording operation is restarted, the recording data output from the encoder 14 is low, and the laser drive circuit 16 outputs a drive signal, the level of which is the same as that when data is reproduced. Accordingly, the power (laser beam) of the laser beam emitted from the optical head 4 is relatively weak (low).

[0074]

That is, if the high level of the recording data were output from the encoder 14, the drive signal output by the laser drive circuit 16 would have a voltage level that is several tens of times greater than when data is reproduced. Thus, the power of the laser beam output from the optical head 4 would be several tens of times greater than that during the data reproduction operation. However, it is difficult to instantaneously activate the laser power of the optical head 4 to several tens of times greater than that during the data reproduction. To do so, a certain time period would be necessary. Thus, it would take time to increase the laser power to a desired level when activating the optical head 4 simultaneously with restarting the recording operation. Such delay would form a non-recording section on the optical disc 32 and produce an interruption in the recording data.

[0075]

Further, when restarting the recording operation, if the optical head 4 emits the laser beam against the wrong data sector of the optical disc 32, data may be recorded (rewrite recorded data) to a sector on which data has already been recorded. In such case, if a high power laser

beam is emitted against a recording layer of the optical head 32 at which recording pits have already been formed, the recording pits may be enlarged and may overlap with recording pits of other sectors or tracks. Consequently, data would not be recorded correctly.

[0076]

Therefore, when recording is interrupted, the recording data is output from the encoder 14 at a low level, and the power of the laser beam of the optical head 4 is decreased so that when recording is restarted, the recording data is output from the encoder 14 at a low level, and the power of the laser beam of the optical head 4 is decreased. Accordingly, the laser power of the laser beam of the optical head 4 does not have to be increased when restarting recording, and the formation of an abnormality in the recording pit is prevented even if the recording data is rewritten when restarting recording.

[0077]

When the two restart signals of the location detection circuits 45, 46 are not synchronously activated (when the two restart signals are activated at different times), the retry determination circuit 44 repeatedly perform data reproduction in the recording restart mode until the two restart signals are synchronously activated.

[0078]

In other words, if an external disturbance occurs for one reason or another (e.g., the application of an external impact to the CD-R drive), the elements 2-22 of the CD-R drive 1 may function erroneously such that the two restart signals are not synchronously activated. Thus, the retry determination circuit 44 repeats data reproduction to avoid the influence of an external disturbance. If the restart signals of the position detection circuits 45, 46 are simultaneously activated, the retry determination circuit 44, the position detection circuit 45, and the address

memory 47 may be deleted.

[0079]

Fig. 2(a) is a schematic view showing a sector of the optical disc 32. Fig. 2(b) is a diagram illustrating the addresses of the buffer memory 13.

Sectors Sn+1, Sn, Sn-1, Sn-2, ..., Sn-m shown in Fig. 2(a) are respectively associated with addresses An+1, An, An-1, An-2, ..., An-m shown in Fig. 2(b).

[0080]

During recording, data is read from the buffer memory 13 in the order of addresses An-m, ..., An-2, An-1, An, and the recording data encoded by the encoder 14 is recorded on the optical disc 32 in the order of sectors Sn-m, ..., Sn-2, Sn-1, Sn. If the buffer underrun determination circuit 20 determines during the recording of data that a bus underrun may occur at address An.

[0081]

As a result, the data of sector Sn, which is associated with address An, is recorded. However, the recording of data is interrupted from the sector Sn+1, which is associated with address An+1. Then, address An is stored in the address memory 47, and the address of the ATIP decoded from the data recorded at sector Sn is stored in the address memory 48.

[0082]

Afterward, when the buffer underrun determination circuit 20 determines that a buffer underrun is no longer likely to occur, data reproduction in the recording restart mode is commenced from sector Sn-m by going back from sector Sn, at which recording was interrupted, by a predetermined number of sectors (in this case, m sectors).

[0083]

When data reproduction is commenced, data is read from the buffer memory 13 from address An-m by going back from address An, at which recording was interrupted, by a

predetermined number of addresses (m addresses). The input data is sequentially read from each address of the buffer memory 13 from address An-m and encoded into recording data by the encoder 14.

[0084]

The signal synchronizing circuit 42 synchronizes the recording data output from the encoder 14 with the data recorded on the sectors Sn-m to Sn of the optical disc 32.

Then, when the address of the data read from the buffer memory 13 matches the address An stored in the address memory 47, the restart signal of the location detection circuit 45 is activated. When the address of the ATIP decoded by the ATIP decoding circuit 10 matches the ATIP address of the sector Sn stored in the address memory 48, the restart signal of the location detection circuit 46 is activated. When the two restart signals of the location detection circuits 45, 46 are simultaneously activated, the retry determination circuit 44 restarts the recording of data.

[0085]

As a result, recording data is recorded continuously from sector Sn+1, which is next to the sector Sn at which data recording was interrupted when a buffer underrun occurred.

It is preferred that the predetermined sector number (m sectors) be sufficient for obtaining time period T1, which is required for the spindle serve circuit 3 to control the spindle motor 2 and the head servo circuit 6 to control the optical head 4, and time period T2, which is required for synchronization by the signal synchronizing circuit 42. For example, m is set at 10 to 30. The time periods T1, T2 increase as the recording speed of the CD-R drive 1 becomes higher, for example, as the recording speed increases from 4× to 8×. Accordingly, the predetermined sector number must be set as a large value.

[0086]

The present invention is not limited to the above embodiments may be modified as described below, in which cases the advantages are the same as or greater than the above embodiment.

(1) In the above embodiment, the rotation of the optical disc 32 is controlled using the constant linear velocity (CLV) method. Thus, the reference signal generated from the oscillation signal of the crystal oscillation circuit 18 is used as an operating clock output from the system clock generation circuit 41 during recording. However, the present invention may be when the rotation of the optical disc 32 is controlled using the constant angular velocity (CAV) method. In such case, a clock synchronized with the wobble component, which is extracted by the wobble decoder 9, is generated and used as the operational clock during the recording of data.

[0087]

(2) In the above embodiment, the access control circuit 19, the buffer underrun determination circuit 20, the recording control circuit 21, and the system control circuit 22 are separate electric circuits. However, they may be replaced by a microcomputer that includes a CPU, a ROM, and a RAM. In other words, the function of each circuit may be achieved by having a microcomputer perform various operations.

[0088]

(3) The above embodiment is applied to a data recorder (e.g., CD-RW drive, MD drive) that uses a rewritable recording medium (e.g., CD-RW standard optical disc, MD standard optical disc). In such case, the occurrence of a buffer underrun error is prevented. This decreases the time required for the recording of data.

[Brief Description of the Drawings]

[Fig. 1] A schematic block diagram showing a CD-R drive

according to an embodiment of the present invention.

[Fig. 2] Fig. 2(a) is a schematic diagram showing a sector of an optical disc in the embodiment, and Fig. 2(b) is a schematic diagram illustrating addresses of a buffer memory in the embodiment.

[Description of the Reference Numerals]

1...CD-R drive

2...spindle motor

3...servo circuit

4...optical head

5...RF amplifier

6...head servo circuit

7...decoder

8...subcode decoding circuit

9...wobble decoder

10...ATIP decoding circuit

11...external connection terminal

12...interface

13...buffer memory

14...encoder

15...encoder internal RAM

16...laser drive circuit

18...crystal oscillation circuit

19...access control circuit

20...buffer underrun determination circuit

21...recording control circuit

22...system control circuit 22

31...personal computer

32...optical disc

41...system clock generation circuit

42...signal synchronizing circuit

43...interrupt/restart circuit

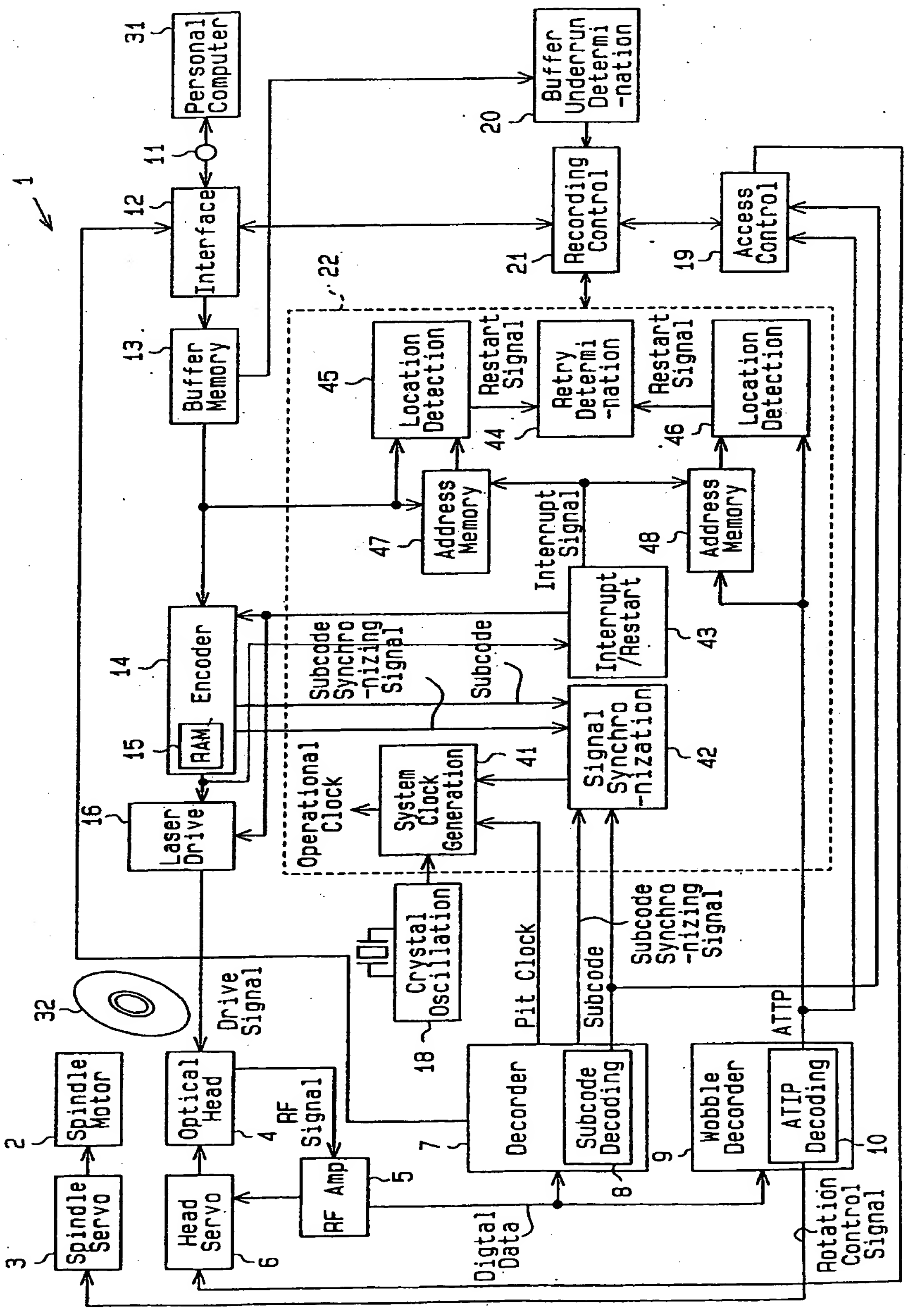
44...retry determination circuit

45, 46...location detection circuits

47, 48...address memories

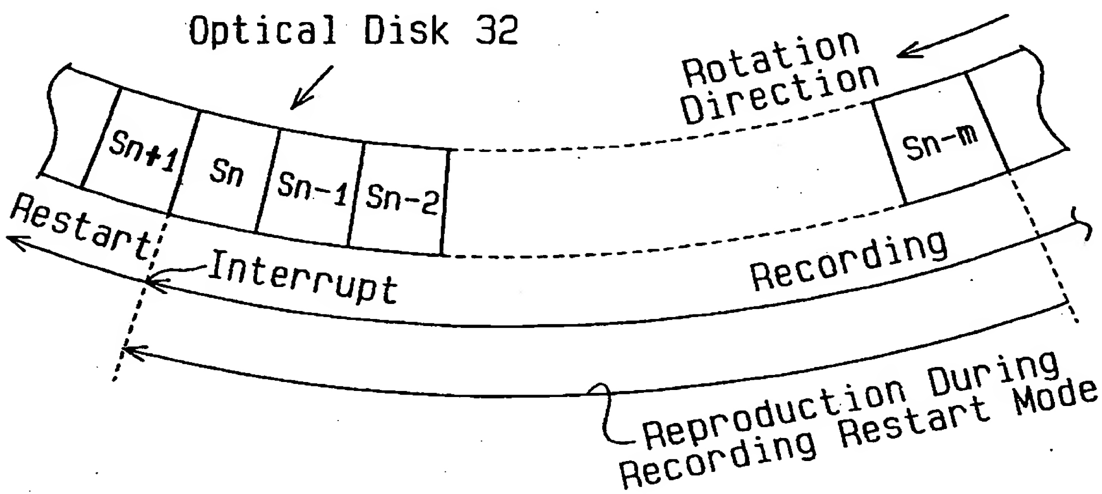
[Title of the Document] Drawings

[Fig.1]

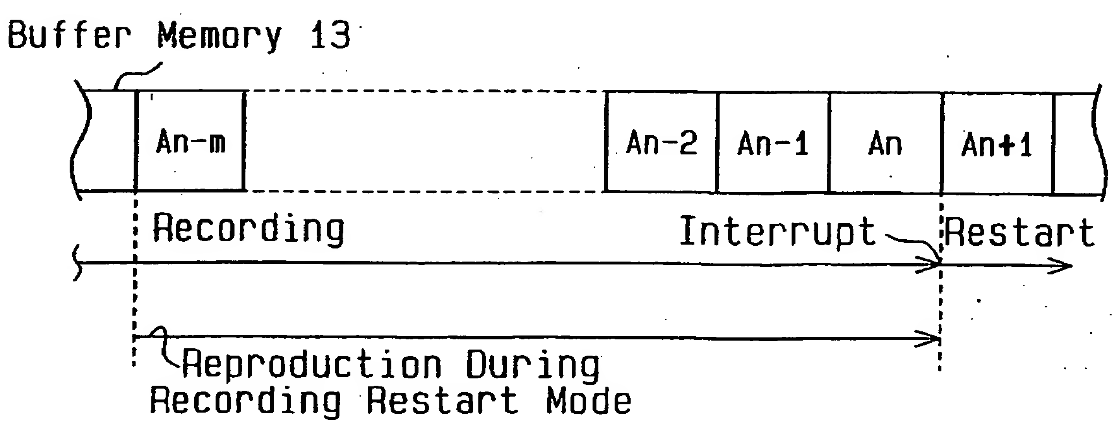

1
Personal Computer
31
11
Interface
12
Buffer Memory
13
Buffer Underrun Determi-nation
20
Recording Control
21
Access Control
19
22
Location Detection
45
Restart Signal
Retry Determi-nation
44
Restart Signal
Location Detection
46
Address Memory
47
Interrupt Signal
Address Memory
48
Interrupt /Restart
43
Encoder
14
RAM
15
Subcode Synchro-nizing Signal
Subcode
Signal Synchro-nization
42
System Clock Generation
41
Operational Clock
Laser Drive
16
Crystal Oscillation
18
Pit Clock
Subcode
Subcode Synchro-nizing Signal
ATTP
32
Drive Signal
Spindle Motor
2
Optical Head
4
RF Signal
Decorder
7
Subcode Decoding
8
Wobble Decorder
9
ATIP Decoding
10
Spindle Servo
3
Head Servo
6
RF Amp
5
Digtal Data
Rotation Control Signal

[Fig. 2]

(a)


Optical Disk 32
Rotation Direction
Sn+1
Sn
Sn-1
Sn-2
Sn-m
Restart
Interrupt
Recording
Reproduction During Recording Restart Mode

(b)


Buffer Memory 13
An-m
An-2
An-1
An
An+1
Recording
Interrupt
Restart
Reproduction During Recording Restart Mode

[Title of the Invention] Abstract

[Abstract]

[Purpose] Ensuring continuity of recording data recorded to a recording medium.

[Means for Solving the Problems] During recording, the input data read from a buffer memory 13 is encoded by an encoder to generate recording data. The recording data is recorded to an optical disc 32. During the recording, if a buffer underrun occurs in the buffer memory 13, the recording data encoded at that point is recorded to the optical disc and recording is interrupted from the next piece of data. Afterward, when the buffer underrun stops occurring, reproduction is started by returning a predetermined number of predetermined sectors on the optical disc 32. This restarts recording from the recording data following the interrupted recording data. An interrupt/restart circuit 43 interrupts the operation of the encoder 14 at a timing in which the recording data output from the encoder 14 becomes low during interruption of the recording. This weakens the laser power of an optical head 4 when restarting recording.

[Selected Drawing] Fig. 1